REMARKS

CLAIMS 1-12

Claims 1-6, 11 and 12 were rejected under 35 U.S.C. §103(a) as being unpatentable over Laroche et al. ("HNM: A Simple, Efficient Harmonic and Noise Model for Speech" 1993, hereinafter Laroche) in view of Gao (U.S. Patent Publication 2002/0035470). Claims 7-10 were rejected under 35 U.S.C. §103(a) as being unpatentable over Laroche in view of Gao and in further view of Seltzer (CMU Speech Group 1999).

Claim 1 provides a method of identifying an estimate for a noise-reduced value representing a portion of a noise-reduced speech signal. Under the method, a portion of a noisy speech signal is decomposed into a harmonic component and a random component. A scaling parameter for at least the harmonic component is determined by determining a ratio of an energy of the harmonic component to an energy of the noisy speech signal. The harmonic component is multiplied by the scaling parameter for the harmonic component to form a scaled harmonic component. The random component is multiplied by a scaling parameter to form a scaled random component. The scaled harmonic component and the scaled random component are summed to form the noise-reduced value representing a portion of a noise-reduced speech signal wherein the portion of the noise-reduced speech signal has reduced noise relative to the portion of the noisy speech signal.

With this amendment, the limitations of claim 4 have been added to claim 1 and claim 4 has been canceled.

As amended, claim 1 is not shown or suggested in the combination of cited art. In particular, none of the cited references multiply a harmonic component by a scaling parameter that is formed by determining a ratio of an energy of a harmonic component to an energy of a noisy speech signal.

In the Office Action, Gao was cited as disclosing a gain factor determined from the ratio of a harmonic component to the energy of the noisy speech signal in page 2, left column, paragraphs 25 and 26. In particular, the equation for the gain factor was said to show a ratio of

the energy of a harmonic component to the energy of a noisy speech signal. Applicants respectfully dispute this assertion.

As noted in paragraph 0024 of Gao, Gao uses a voice activity detector to identify frames associated with only noise (no speech). From these noise frames, Gao is able to estimate a signal-to-noise ratio for each sub-band. Based on this definition, the equation for the gain factor indicates the ratio of the magnitude of a speech signal to the magnitude of the combination of speech and noise in the noisy speech signal.

The numerator in this ratio, however, includes both the harmonic components and the random components of the speech signal. Because noise affects the harmonic components and the random components of speech differently, i.e. some portions of the noise are harmonic while other portions of the noise are random, the speech-to-noisy signal ratio shown in Gao is substantially different from the harmonic energy to noisy speech signal energy ratio found in claim 1. The difference can be seen from a simple example. If a speech signal includes a portion that is highly harmonic and a second portion that is highly random, but both portions have the same magnitude, the ratio shown in Gao will be the same for both regions. However, in the invention of claim 1, the ratio of the harmonic energy to the total energy of the noisy speech signal will be higher in the portion of the speech signal that has only harmonic components and will be lower in the portions of the speech signal that only have random components. Thus, substantially different ratios will be produced in the invention of claim 1 than in Gao.

In addition, the combination of cited art does not show or suggest using the ratio of Gao as a scaling parameter for scaling a harmonic component. In the Office Action, the amplitude A_k of a harmonic component in Laroche was indicated to be the scaling parameter of the harmonic component in rejecting claim 1. In rejecting claim 4, the scaling parameter is changed to being the speech-to-noisy speech ratio of Gao. Thus, the Office Action is implying that it would be obvious to replace the amplitudes A_k of the harmonic components in Laroche with the speech-to-noisy speech ratio of Gao. However, there is no suggestion in either Laroche or Gao for substituting the amplitude of the harmonic component with the speech-to-noisy signal ratio found in Gao. Further, the fact that Laroche discusses an estimation technique in section 3

designed specifically to determine the value of A_k so as to minimize the criterion shown in EQ. 3 indicates that A_k should be chosen carefully. Substituting the ratio found in Gao for the amplitudes would make this determination meaningless and would produce amplitudes that do not accurately depict the harmonic components of the speech. As such, those skilled in the art would never make the substitution suggested by the Examiner.

Since none of the cited references show or suggest a scaling parameter that is the ratio of an energy of a harmonic component to an energy of noisy speech signal and since none of the cited references show or suggest multiplying such a scaling parameter by a harmonic component to form a scaled harmonic component, the invention of claim 1 and claims 2, 3 and 5-12 which depend therefrom are patentable over the cited art.

Claim 2

Claim 2 depends from claim 1 and includes a further limitation wherein decomposing the noisy speech signal comprises modeling the harmonic component as a sum of harmonic sinusoids. In the Office Action, the harmonic component was said to be the exponent. Further, it was asserted that the multiplication of the harmonic component by the parameter A_k was done through the multiplication of the individual harmonic sinusoids. It was further asserted that the multiplication of the parameters before the summing or after the summing is equivalent since the A_k could have been factored out and multiplied later as a vector. Applicants respectfully dispute this assertion.

In equation 1 of Laroche, $A_k(t)$ is the complex amplitude at time t of the *k*th harmonic. As such, each A_k is tied to the exponent since both are dependent on the harmonic k. As a result, the multiplication must take place within the summation and not external to the summation. In fact, if the amplitude A_k is factored out of the summation and then multiplied later after the summation is performed it would produce a different result than if each A_k is multiplied by its respective exponent and the resulting products are summed together.

The difference can be seen by a simple example. Say there are three harmonics such that k={1, 2, 3}, then the summation of EQ. 1 without factoring would be represented as:

$$\hat{s}_d(t) = A_1(t)\exp(j1(t-t_i)\omega_0(t)) + A_2(t)\exp(j2(t-t_i)\omega_0(t)) + A_3(t)\exp(j3(t-t_i)\omega_0(t))$$

Note that the summation forms a single scalar value, not a vector, and that each amplitude is multiplied by one exponent term.

However, if A_k is factored out into a vector as proposed by the Examiner, equation 1 would change to:

$$\hat{s}_d(t) = \begin{bmatrix} A_1(t) \\ A_2(t) \\ A_3(t) \end{bmatrix} (\exp(j1(t-t_i)\omega_0(t)) + \exp(j2(t-t_i)\omega_0(t)) + \exp(j3(t-t_i)\omega_0(t)))$$

This multiplication would result in a vector, such that:

$$\hat{s}_d(t) = \begin{bmatrix} A_1(t)(\exp(j1(t-t_i)\omega_0(t)) + \exp(j2(t-t_i)\omega_0(t)) + \exp(j3(t-t_i)\omega_0(t))) \\ A_2(t)(\exp(j1(t-t_i)\omega_0(t)) + \exp(j2(t-t_i)\omega_0(t)) + \exp(j3(t-t_i)\omega_0(t))) \\ A_3(t)(\exp(j1(t-t_i)\omega_0(t)) + \exp(j2(t-t_i)\omega_0(t)) + \exp(j3(t-t_i)\omega_0(t))) \end{bmatrix}$$

Note that in the result produced by the Examiner's suggestion, each amplitude is multiplied by all of the exponents instead of multiplying just one of the exponents in the non-factored equation. Also note that the result produced by factoring out the A_k and forming a vector produces a vector and not a scalar quantity. Thus, the suggestion for factoring out the A_k and forming a vector from it and then multiplying it by the summation not only produces a different result from that produced by equation 1, but also forms a vector instead of forming a scalar as found in equation 1.

Since A_k cannot be factored out of EQ. 1 as suggested by the Examiner, A_k cannot be considered a scaling parameter that is multiplied by a sum of sinusoids that represents a harmonic component. Instead, A_k itself forms part of the definition of the sum of sinusoids since it represents the amplitude of a harmonic in the harmonically related sinusoidal components. This can be seen in the paragraph before EQ. 1 where the sums of harmonically related sinusoidal components with piece wise linearly varying complex amplitudes is said to represent the deterministic component of the speech signal. Thus, the piece wise linearly varying complex amplitude, $A_k(t)$, forms part of the definition of the sum of sinusoids and is not a scaling

parameter that is multiplied by the sum of sinusoids to form a scaled harmonic component. As such, claim 2 is further patentable over the cited art.

CLAIMS 13-25

Claims 13-16 and 18-24 were rejected under 35 U.S.C. §103(a) as being unpatentable over Laroche in view of Gao. Claims 17 and 25 were rejected under 35 U.S.C. §103(a) as being unpatentable over Laroche in view of Gao in further view of Seltzer.

Independent claim 13 provides a computer-readable medium having computer-executable instructions for performing steps that include identifying a harmonic component and a random component in a noisy speech signal wherein identifying the harmonic component comprises modeling the harmonic component as a sum of harmonic sinusoids, each sinusoid having an amplitude parameter. A weighted sum is formed to produce a noise-reduced value representing a noise-reduced speech signal that has reduced noise compared to the noisy speech signal wherein the weighted sum is formed by multiplying the harmonic component by a scaling value for the harmonic component to form a scaled harmonic component, multiplying the random component by a scaling value for the random component to form a scaled random component and adding the scaled harmonic component to the scaled random component to produce the noise reduced value. The scaling value for the harmonic component is different than the scaling value for the random component. A noise-reduced value is then used to perform speech recognition.

As amended, claim 13 is not shown or suggested in the combination of cited art. In particular, none of the cited references show or suggest forming a weighted sum of a scaled harmonic component and a scaled random component where the scaled harmonic component is formed by multiplying a harmonic component modeled as a sum of harmonic sinusoids having amplitude parameters by a scaling value.

In the Office Action, the harmonic component identified in Laroche as being modeled by a sum of harmonic sinusoids does not have both a scaling value and amplitude parameters. In the Office Action, the amplitude parameters $A_k(t)$ of Laroche were said to be the

scaling parameters. However, $A_k(t)$ cannot be both the scaling parameters and the amplitude parameters. Since Laroche defines $A_k(t)$ as the complex amplitude, Laroche does not show a scaling value multiplied by the harmonic component to form a scaled harmonic component. Similarly, none of the other references show or suggest multiplying a harmonic component by a scaling value for a harmonic component to form a scaled harmonic component. As such, claim 13 and claims 15-17, 20, 21 and 23-25 are patentable over the cited art.

Claims 20, 21 and 23

Claims 20, 21 and 23 are additionally patentable over the cited combination of art. In claim 20, a scaling value is determined for the harmonic component by determining a ratio of an energy of a harmonic component to an energy of the noisy speech signal. As noted above, none of the cited art shows such a ratio and it would not be obvious to those skilled in the art to use the speech signal-to-noisy speech ratio of Gao as a scaling value for scaling a harmonic component. As such, claims 20, 21 and 23 are additionally patentable over the cited art.

CONCLUSION

In light of the above remarks, claims 1-3, 5-13, 15-17, 20, 21, and 23-25 are in form for allowance. Reconsideration and allowance of the claims is respectfully requested.

The Director is authorized to charge any fee deficiency required by this paper or credit any overpayment to Deposit Account No. 23-1123.

Respectfully submitted,

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